ALLEN TRANSLATION SERVICE
T6241 Translated from German 1

(19) FEDERAL REPUBLIC OF GERMANY
GERMAN PATENT OFFICE

(12) Unexamined patent application
["Offenlegungsschrift"]
(10) DE 196 54 990 A 1

(51) Int. Cl.[6]:
A 61 M 27/00
A 61 M 1/00
A 61 B 5/03
G 08 C 17/00
G 01 P 5/14
G 01 V 1/22

(21) Reference No.: 196 54 990.6
(22) Application date: 10.29.96
(43) Date laid open to public inspection: 6.18.98
(66) Internal priority:
196 36 571. 6 09.09.96

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The following data have been taken from the documents which were submitted by the applicant

A request for examination in accordance with § 44 of the Law on Patents has been submitted.

(54) Implant for the controlled draining off of cerebrospinal fluid

(57) The invention pertains to an implant for the controlled draining off of cerebrospinal fluid, especially for the therapy of hydrocephalus, with a catheter which is positioned under the skin and whose first free end is led to a location in the brain from where excess cerebrospinal fluid is capable of being drained off, and whose second free end is led to a location in the body from where the excess cerebrospinal fluid is capable of being taken up by the body, and with a valve that has been introduced into the catheter along its length. In order to create further adjustment possibilities and/or monitoring possibilities for the implant, a network unit is provided to which a flow sensor is connected which measures the quantity of fluid flowing through the catheter per unit time.

Specification

The invention pertains to an implant for the controlled draining off of cerebrospinal fluid, especially for the therapy of hydrocephalus, in accordance with the preamble of Patent Claim 1.

The term "water on the brain" (hydrocephalus in Latin) is understood to mean the disease which comprises an increased accumulation of cerebrospinal fluid in the interior of the skull. In this way, the sensitive equilibrium involving the production of cerebrospinal fluid and its uptake is disrupted so that the cerebrospinal fluid is permanently, intermittently or occasionally under an abnormally elevated increased pressure.

It is known that one can implant a drainage system, that is termed a "shunt", for the therapy of hydrocephalus. The objective is pressure normalization by creating controlled drainage. In this connection, the shunt forms a unit comprising a catheter and a valve. The first free end of the catheter is led through the skull and the hard cerebral membrane and into the interior of the brain. Whereas the catheter consists of a stiffened material at its first free end, the catheter changes over into a silicone tube at the upper edge of the skull, whereby the silicone tube can be positioned flexibly in the body. A valve is introduced along its length and provides pressure-controlled draining off of the cerebrospinal fluid.

The valves that have been used so far are a kind of safety valve which block the return flow of fluid. Thus, for example, valves are known in which a sphere is pressed into a cone by means of a spring. If a certain pressure of the cerebrospinal fluid has built up at the inlet of the valve, then the sphere is pressed out of the cone against the force of the spring so that liquid can flow through the valve. In the case of certain valves, a mechanical adjustment possibility from the outside is also provided with which the opening pressure, at which the valve opens for draining off the cerebrospinal fluid, is capable of being adjusted within coarse ranges. Reverse flow in the inverse flow direction is prevented by the seating of the valve sphere in the cone. The prevention of reverse flow is necessary since even one drop of blood could cause complete sticking in such a mechanically constructed valve and could thus make the valve incapable of functioning. Thus it is also known that one can provide a widened region in the silicone tube (pump chamber) and an additional non-return valve in front of the valve. As a result of pump-like pressing on the widened out region, any contaminants that are present can then be removed.

The positioning of the valve in the body is, in principle, arbitrary. However, it has proven to be advantageous to insert the valve under the skin behind the ear. The second free end of the catheter, which leads away from the valve, is led from there under the skin and into the abdominal cavity where the excess cerebrospinal liquid can be taken up by the body.

Such shunt systems have been implanted for virtually 40 years for the therapy of hydrocephalus. However, known shunt systems do not operate reliably but exhibit over-drainage or under-drainage during everyday operation.

Over-drainage produces emptying of the interior of the brain and leads, as a consequence, to spontaneous bleeding and headache. In addition, over-drainage can lead to the collapse of the interior of the brain and hence produces damage in the central nervous system (slot valve syndrome). Under-drainage is also dangerous for the patient since cerebral matter can be destroyed by the increasing pressure. However, therapy is also possible via moderate under-drainage since the natural processes for the absorption of the cerebrospinal fluid can then be stimulated again.

The problem of over-drainage or under-drainage is produced, on the one hand, as a result of the existing type of valve constructions themselves. Thus valves from the same manufacturing series exhibit a range of opening pressure values. On the other hand, however, the optimum opening pressure, which is to be set up, is dependent on the individual patient in question and it cannot be determined prior to the implantation of the shunt system. A further problem is the adaptation of the hydraulic characteristics of the implant to the different bodily positions. Thus, on straightening the body, the pressure in

the brain falls but an additional pressure gradient is created as a result of the difference in height between the inlet and the outlet of the catheter which leads to the abdomen. However, even at this pressure value, the valve should drain off only the quantity of liquid which is precisely necessary. In total, the physician who is providing treatment therefore has only very limited possibilities for diagnosis or therapy after the implantation. Non-optimal adaptation of the valve to the patient or malfunctioning can be recognized only by symptomatic complaints e.g. headache or by means of a computer tomogram in an advanced state of ill-health. Even in the case of valves with the possibility for adjusting the opening pressure mechanically, only very inaccurate data are available to the physician as to how he should set up the new opening pressure. In most cases, only a renewed operation remains as the last possibility for therapy, whereby such an operation is always associated with heavy burdens and risks for the patient and high costs for the general public.

The task for the present invention is therefore to create an implant of the type which permits improved monitoring and/or adjustment of the valve even after its implantation.

This task is accomplished by the characteristic features which are listed in Patent Claim 1. In accordance with the invention, a measurement unit is provided to which a flow sensor has been connected which measures the amount of fluid flowing through the catheter per unit time, whereby the measurement unit for adjusting and/or monitoring the valve collaborates with an adjustment unit and/or with a control unit which is located outside the body. The invention also creates additional monitoring possibilities for the valve. As is known, the measurement of flow is not essential for monitoring the implant since the pressure of the cerebrospinal fluid is ultimately the decisive monitoring parameter. However, one has an additional possibility for controlling the functioning of the valve via the flow measurement.

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The flow sensor preferably consists of a defined flow resistance and a pressure sensor, whereby the pressure sensor measures the pressure drop across the flow resistance. The difference in pressure, which is measured by the pressure sensor, is then a function of flow so that the flow of fluid through the catheter is capable of being determined in this way. Another preferred form of embodiment of a flow sensor can comprise the feature that the flow sensor consists of a compensation regulator which compensates the difference in pressure between the inward and outward flow of fluid in a measurement tube via a gear pump which is introduced into the measurement tube. This compensation principle is also suitable for the measurement of the smallest flow quantities.

A further way of accomplishing the aforementioned task and for which independent patent protection is also claimed comprises the characterizing features of Patent Claim 4. In accordance with the invention, a measurement unit is provided to which a position sensor has been connected which measures the position of the body relative to the earth's acceleration vector, whereby the measurement unit for adjusting and/or monitoring the valve collaborates with an adjustment unit and/or with a control unit which is located outside the body [translator: an assumed grammatical error has been corrected] The difference in pressure between the first and the second free end of the catheter can serve, for example, as a measure of the position of the patient.

In accordance with a preferred form of embodiment, the measurement unit and the adjustment unit are integrated into a telemetry unit, whereby a data transmission system and/or an energy transmission system is capable of being established between the telemetry unit and a control unit which is located outside the body. Thus comprehensive control possibilities and/or adjustment possibilities for the implant are provided by the telemetry unit. Thus, in a first step, it is possible to provide a measurement unit in the telemetry unit to which at least one sensor has been connected for the measurement of at least one condition of the implant. Thus, for example, the pressure at the first free end of the catheter and the flow through the catheter can be

measured and transmitted from the interior of the body to a control unit via the telemetry unit. Alternatively or additionally, set-up values can be transmitted from the control unit to the telemetry unit via the telemetry unit which are then forwarded to the actors which are connected thereto. Thus, in particular, it is possible to construct the valve in the form of an adjustment valve and thus to modify the flow through the catheter from the outside. In addition, it is possible that a regulator be provided in the telemetry unit which automatically adjusts the adjustment valve as a function of the measured values, that are determined, and a target valve. The target value can, in turn, be prescribed and modified via the control unit.

The implant in accordance with the invention has a series of advantages relative to conventional implants. Thus it is possible to determine the behavior of the implant even under everyday conditions and to check it at regular intervals of time. In the event that abnormalities in the system characteristics are established, the valve properties can be modified in the desired way. This can take place, on the one hand, via the telemetry unit by appropriately provided actors, or appropriate adjustment possibilities are provided at the valve, whereby these adjustment possibilities can be altered by mechanical influences on the valve from the outside. In the event that an appropriately fine adjustable actor is present in the valve, it would be possible to reactivate the resorption capability of the patient by means of controlled therapy. This is possible by means of slight under-drainage which can be adjusted, in accordance with the invention, to the patient-specific requirements. Thus, in the ideal case, the implant can become superfluous over the course of a period of years.

NASA system uses external power.

It is especially advantageous if, in addition to the data transmission system, an energy transmission system is also possible between the telemetry unit and the control unit. As a result of this, a storage battery can be charged up which serves - in parallel to a battery which is present in the implant or even on its own - for the supply of energy to the electrical and electronic components that are present in the implant.

In accordance with a preferred form of embodiment, the valve is integrated into the telemetry unit. In particular, the situation can be provided, that the valve and the telemetry unit form an integrated unit to which the first free end and the second free end of the catheter are capable of being connected and which is capable of being implanted beneath the skin. A location behind the ear or under the collar bone is regarded as being a preferred location for implantation.

One or more pressure sensors are expediently connected to the measurement unit, whereby the pressure sensors measure the pressure drop at one or more locations in the catheter. Thus, in particular, a pressure sensor can be provided which measures the pressure drop across the valve, the absolute pressure of the cerebrospinal fluid or the pressure difference between the first and second free end of the catheter. In this regard, use is preferably made of micro-mechanical flow sensors which are integrated on to a silicon chip and are thus capable of being manufactured in an especially small size in terms of their construction.

In accordance with a further preferred form of embodiment, the feature is provided that a memory for the measured values is incorporated into the measurement unit, whereby the previous measured values are capable of being stored in the memory. In this way, the data of the sensors, which are connected to the measurement unit, can be recorded even under everyday conditions and they can be transmitted to the control unit via the telemetry unit during a routine examination by the physician who is providing treatment. An evaluation of the measured data in question can then take place in the control unit, after which further therapeutic steps can be determined. In this way, the monitoring of conventional passive safety valves with reverse flow blockage devices becomes possible.

In accordance with a further preferred form of embodiment, the feature is provided that the telemetry unit has a computer unit which evaluates the measured values, which are determined by the measurement unit, in terms of prescribed target values. For example, the measured flow through the implant can be compared with prescribed typical flow characteristics, whereby the storage of the data in question takes place only in the event of a defined deviation. In this way, a pre-selection of the relevant data can be effected in the case where large quantities of data are incident on the measurement unit in order to be able to store these in the memory for the measured values over a period of time which is as long as possible. It is especially advantageous if test routines are implanted in the computer unit which check the functional capability of the implant.

In order to control the flow of fluid through the catheter by the telemetry unit, consideration can basically be given to three types of valves namely, proportional valves, switch-type vales and overflow valves, which exhibit a change in valve characteristics. In the case of proportional valves, the flow resistance is continuously adjusted, for example, by means of a piston-rod, by means of a sphere, which is capable of moving in a cone, or by squeezing the tube. Thus the proportional valve is active since it requires energy for working against the pressure of the liquid. In contrast to this, switch-type valves have only a closed state and an opened state between which switching takes place back and forth. The timing relationship between the two states determines the average flow. Thus the switch-type valve is also an active valve since work has to be done against the pressure of the liquid during switching. In the case of overflow valves with a change in valve characteristics, by contrast, one is dealing with passive valves with active adjustment of the opening pressure. The valve itself is energy free in its action and the adjustment energy derives from a passive energy store, for example a pre-tensioned spring.

A so-called inchworm motor, for example, is suitable as the drive unit for the various valve embodiments, whereby this motor consists of two piezoelectric supporting elements which hold or release a piezoelectric rod contra-synchronously depending on the direction of its expansion. The expansion of the piezoelectric rod or the retaining function of the retaining elements is thereby achieved by applying a voltage to the piezoelectric elements in question. Another possibility comprises the feature that the drive unit is an expandable bellows, whereby the volume is capable of being changed as a result of a phase transition in the medium that is enclosed in the bellows. The phase transition can be produced e.g. by heating so that the valve seating can be closed or opened. A further possibility for the drive unit comprises the feature that the drive unit is a miniaturized electric motor with a self-restraining transmission system, whereby the self-restraining transmission system converts the rotational motion of the axis of the motor into linear movement of the piston-rod. As a result of the self-restraining transmission system, additional energy does not need to be supplied for the retaining force of the piston-rod so that such a drive unit is especially economical in terms of energy. Finally, a coil which is immersed in a permanent magnetic field is also conceivable as a drive unit.

Thus if a possibility for adjusting the valve exists, then completely new therapy possibilities open up for the physician who is providing treatment since the physician can re-adjust the flow resistance of the valve after evaluating the measurement data that are transmitted by the telemetry unit. This can also take pace automatically by the control unit if necessary.

Additionally or alternatively to the possibility of adjusting the valve by the control unit, a regulator can also be provided that - depending on at least one measured parameter of the valve which relates to its status and one prescribed target value - determines an adjustment parameter for the adjustment valve in such a way that the drainage characteristics of the cerebrospinal fluid correspond to the target value. Such a regulator can be integrated into the control unit or even into the telemetry unit.

In the event that the regulator has been integrated into the control unit, the control unit takes over the new adjustment of the valve during a routine consultation with the physician who is providing treatment. If, however, the regulator is integrated into the telemetry unit, then the telemetry unit can continuously and automatically undertake the adjustment of the valve on the basis of the recorded measured data. In this case, the necessary data transferal to the control unit can be restricted to a minimum since the regulator, which has been integrated into the telemetry unit, inherently ensures optimum functioning of the valve. In the case of routine examinations, however, it will be expedient to transfer the measured data, which are recorded under everyday conditions of the implant, to the control system and also, if required, to provide a new target value for the regulator via the control system.

A simple form of providing the regulator could, for example, comprise the feature that the regulator is a PI regulator which converts the regulating difference between a prescribed target pressure value and a measured pressure of the cerebrospinal fluid into an adjustment parameter for the drive unit of the adjustment valve. However, all other types of suitable regulators are conceivable of course.

In accordance with a further preferred form of embodiment, the feature is provided that the telemetry unit and the control unit have an oscillating circuit with an inductance in each case, whereby the oscillating circuit is capable of being tuned by the telemetry unit for the transferal of measured values and the oscillating circuit is capable of being tuned by the control unit in the case of the transferal of adjustment values and that data transferal takes place in a contact free manner by means of inductive coupling of the inductances. In this way, bi-directional data transferal is possible without a large demand for energy by the telemetry unit. Instead of evaluating the information content of the transferred frequency, one can also use its energy content for charging up a storage battery or a capacitor which serve, for their part, for supplying energy to the telemetry unit. In this way, the size and weight of the telemetry unit can be further reduced since regular charging up of an energy store, which is provided in the telemetry unit, is possible during the follow-up examinations which are in any case necessary.

The control unit is expediently connected to a computer system which evaluates the measured values that have been transmitted and calculates the adjustment values that are to be transmitted. For example, the control unit can consist of a manual sensing head which is introduced in the vicinity of the implanted telemetry unit for data transfer purposes. In this connection, only the elements which are required for data transfer are contained in the sensing head whereas the actual evaluation takes place in the computer system.

Further characteristics and advantages of the invention are elucidated in more detail on the basis of an example of an embodiment that is illustrated in the drawings. The following aspects are shown in these drawings.

Fig. 1 shows a schematic illustration of the components which are connected to the telemetry unit;

Fig. 2 shows a block circuit diagram for the telemetry unit;

Fig. 3 shows an electrical sketch of the principle of the circuit diagram for the transfer of data from the telemetry unit to the control unit;

Fig. 4 shows a diagram of the principle of the electrical circuit for the transfer of data from the control unit to the telemetry unit;

Fig. 5 shows a schematic representation of the entire implant;

Fig. 6 shows a schematic representation of an actor and an adjustment valve;

Fig. 7 shows a schematic representation of a proportional valve;

Fig. 8 shows a schematic representation of a switch-type valve;

Fig. 9 shows a schematic representation of a flow sensor and

Fig. 10 shows a schematic representation of a flow sensor with a compensation regulator;

Fig. 1 shows a schematic representation of the components which are connected to the telemetry unit. The telemetry unit 1 is implanted under the skin of the patient at a suitable location in the body, whereby a sensing head 2 is aligned with the surface of the skin. A catheter 3 is led through the skullcap 4 via its first free end 5 into the interior of the brain and is then positioned in such a way under the skin of the patient that the second free end 6 terminates in the abdominal cavity of the patient. A valve 7 is introduced along the length of the catheter 3, whereby the flow resistance of the valve is capable of being changed via a drive unit 8. The valve 7 is preferably implanted in the vicinity of the telemetry unit or forms an integrated unit together with this.

Three sensors 9, 10, 11 are connected to the telemetry unit 1, whereby the sensors record the different conditions of the cerebrospinal fluid which is flowing through the catheter 3. The pressure in the abdominal cavity or the interior of the brain is capable of being measured via the sensors 9 and 11 whereas, by contrast, the flow velocity in the catheter 3 is capable of being measured by the sensor 10. Conversely, the drive unit 8 is electrically connected to the telemetry unit.

In case of necessity, a second sensing head 12 can be placed on the skin of the patient from the outside and in the vicinity of the sensing head 2, whereby the second sensing head is connected to a control unit that is not shown in further detail. In this regard, the control unit can consist of a computer system, for example.

Fig. 2 shows a block circuit diagram of the telemetry unit. The telemetry unit consists of a measurement unit 20, a regulator 21, a memory and computer unit 22, an adjustment unit 24 and a communication unit 24. In accordance with Fig. 1, the sensors 9, 10, 11 are attached to the measurement unit 20. In this way, processing and AD conversion of the sensor signals take place in the measuring unit 20. The digital measured values from the sensors are then forwarded to the regulator 21 and also to the memory and computer unit 22. The regulator 21 converts the measured values from the measurement unit 20 into a target value on the basis of the corresponding regulation algorithm and as a function of the prescribed target value and the target value is fed to the adjustment unit 23. The adjustment unit 23 converts the adjustment value in question, which is supplied by the regulator 21, into an analog value by means of a DA [sic] converter and processes this value accordingly so that the analog adjustment value can be fed to the actor 8. As a result of the actor 8, alteration of the flow resistance of the valve 7 take places in accordance with Fig. 1 so that, in turn, the measurement parameters of the sensors 9, 10, 11 change and thus the regulating circuit is closed. The memory and computer unit 22 additionally determines the digital measured values and the digital adjustment values and stores these at regular intervals of time. In addition, an internal computer unit monitors the values that have been determined and, if required, changes the parameters of the regulation algorithm. Such an adaptation of the regulation parameters can also be limited to cases in which data transfer takes place via the external control unit. In this case, the computer unit can therefore be installed in the control unit.

In order to implement data transfer between the telemetry unit and an external control unit, the sensing head 12 of the control unit is placed in the vicinity of the sensing head 2 of the telemetry unit in accordance with Fig. 1. In order to transfer the values which are stored in the memory and computer unit 22 to the control unit, the values from the communication unit 24 are read out of the memory and computer unit 22 [words missing] for data transfer and are supplied to the sensing head 2. A more detailed description

of data transfer takes place in Fig. 3 in this connection. Data transfer between the control unit and the telemetry unit is also established in the converse manner; a corresponding description is to be found in Fig. 4.

Fig. 3 shows a diagram of the principle of the electrical circuit for the transfer of data from the telemetry unit to the control unit. The transfer direction is indicated by the arrow A. The values, which are converted in the communication unit 24, are supplied to the sensing head 2 and are forwarded from there to a voltage frequency converter 30 which periodically actuates a switching transistor 31; as a result of this, the resonance frequency of the oscillating circuit, which is formed from C and L1, is correspondingly changed by the switching frequency. As a result of this, the resonance frequency of the oscillating circuit, which is formed by C and L2, is tuned in the sensing head 12, whereby the transfer energy is supplied by the oscillator 34 which is located in the sensing head 12. The resonance frequency, which has been modulated in this way, is supplied via the resistance R and via the frequency voltage converter in the form of an analog voltage to the control unit 33.

Fig. 4 shows the principle of the electrical circuit diagram for the transfer of data from the control unit to the telemetry unit. The transfer direction is indicated by the arrow B. In this case, the frequency of the oscillator 34 changes in accordance with the values that are to be transferred from the control unit 33. Data transfer otherwise takes place analogously in accordance with Fig. 3.

Fig. 5 shows a schematic representation of the entire implant. A hole 50 is introduced in the skull cap on top of the skull, whereby the first free end 5 of the catheter 3 is introduced into the hole. The catheter 3 is positioned below the skin of the head and ends with its second free end in the abdominal cavity. The telemetry unit and the valve form an integrated unit 51 which, as illustrated in Fig. 5, can be implanted behind the ear of the patient or, preferably, under the collar bone. An area of widening 52, in which silicone tubing is provided that can be pressed in a pump-like manner for the removal of any possible blockages or regions [of the tube] which are stuck together, is located in front of the integrated unit 51.

Fig. 6 shows a schematic representation of an actor 8 and a passive valve 7. The actor 8 consists of a miniaturized electric motor 60 which is capable of being switched on and off via the terminals 61. The drive shaft of the electric motor 60 is connected to a shaft coupling unit 62 via a spindle shaft 63. The spindle shaft 63 has a screw thread 64 on which a spindle nut 65 runs. The spindle nut 65 is connected in a jointed manner via a lever arm 66 which projects into the valve chamber 72 of a valve 7 and at which the housing 73 is mounted in a rotatable manner on bearings.

The valve has an inlet 68 which opens out into a cone 69. The cone 69 is capable of being closed by a sphere 70, whereby the compressive force is supplied by a spring 71. The spring 71 is connected in such a way to the lever arm 66, which projects into the valve chamber 72, that the compressive force on the sphere 70 is capable of being changed by an adjustment of the lever arm.

A voltage is applied to the terminals 61 in order to adjust the valve characteristics. The opening pressure of the valve 7 can be increased or reduced in this way depending on the direction of rotation of the spindle shaft 63. If the spindle nut 65 accordingly moves in the direction that is characterized by A, then the opening pressure increases; if the spindle nut 65, by contrast, moves in the direction which is characterized by B, then the opening pressure of the valve 7 decreases.

Fig. 7 shows a schematic representation of a proportional valve. The proportional valve consists of a miniaturized direct current motor 80 whose shaft drives a spindle 81 with a screw thread. A ring 82 with a screw thread runs on the spindle 81 with a screw thread together with a piston-rod 83 whose

end projects into a valve seating 84. The valve seating 84 is surrounded by a valve housing 85 with an inlet 86 and an outlet 87 so that the flow resistance between the inlet 86 and the outlet 87 is capable of being changed by adjusting the valve seating 84.

Fig. 8 shows a schematic representation of a switch-type valve. The switch-type valve consists of a valve housing 90 in whose interior a membrane 91 oscillates back and forth between two states. In the first state, the inlet 92 is closed by the membrane 91 whereas in the second state, the inlet 92 has been opened so that liquid can stream through the valve housing 90 toward the outlet 93. A coil 94, whose polarity is capable of being switched around, is located on the membrane 91. For this purpose, permanent magnets, which are arranged with opposing poles, are attached to the adjacent side walls of the valve housing. As a result of this, the switching state of the membrane 91 can be changed by applying a voltage to the coil which is capable of having its polarity switched around.

Fig. 9 show a schematic representation of a flow sensor. The flow sensor consists of a measurement tube 100 in which a flow resistance 101 has been introduced. Liquid is led through the lines 103 and 104 to a pressure sensor 102 in front of and behind the flow resistance so that the pressure drop is measured via the flow resistance 101. The difference in pressure which is measured by the pressure sensor 102 in this way is a function of the flow. Conventional commercial pressure sensors can be considered for use as the pressure sensors, whereby micro-mechanical pressure sensors are especially suitable because of miniaturization.

Fig. 10 shows a schematic representation of a flow sensor with a compensation regulator. The flow sensor has a gear pump with gear wheels 110 and 111 which are driven by a transmission system 112 and an electric motor 113. The gear wheels 110 and 111 are introduced into a measuring tube 114 in such a way that they accelerate liquid, which is located in the measurement tube 114, in the direction of the arrow 122 on applying an adjustment signal 121.

The difference in pressure of the liquid, which is flowing in the measuring tube, is measured between the locations 115 and 116 by the pressure sensor 117. The initial signal 118 from the pressure sensor is supplied to a regulator 120 together with a target value 119. The target value 119 is preferably equal to zero so that, via the gear pump, the regulator 120 compensates the difference in pressure which is measured by the pressure sensor 117. The adjustment parameter 121 in this case is directly proportional to the flow through the measurement tube.

Patent claims

1. Implant for the controlled draining off of cerebrospinal fluid, especially for the therapy of hydrocephalus,
with a catheter which is positioned under the skin whose first free end is led to a location in the brain from where excess cerebrospinal fluid is capable of being drained off and whose second free end is led to a location in the body from where the excess cerebrospinal fluid is capable of being taken up by the body, and
with a valve that has been introduced into the catheter along its length, characterized by a measurement unit to which a flow sensor has been connected which measures the amount of fluid flowing through the catheter per unit time, whereby the measurement unit for adjusting and/or monitoring the valve collaborates with an adjustment unit and/or a control unit which is located outside the body.

2. Implant in accordance with Claim 1, characterized by the feature that the flow sensor consists of a defined flow resistance and a pressure sensor, whereby the pressure sensor measures the drop in pressure across the flow resistance.

3. Implant in accordance with Claim 1, characterized by the feature that the flow sensor consists of a compensation regulator which compensates for the difference in pressure between the inlet and outlet of a measurement tube via a gear pump that is introduced into the measurement tube.

4. Implant in accordance with the preamble of Patent Claim 1, characterized by a measuring unit to which a position sensor has been connected and which measures the position of the body relative to the earth's acceleration vector, whereby the measuring unit collaborates with an adjustment unit and/or a control unit which is located outside the body in order to adjust and/or monitor the valve.

5. Implant in accordance with one of the Claims 1-4, characterized by the feature that the measurement unit and the adjustment unit are integrated into a telemetry unit, whereby a data transmission system and/or an energy transmission system is capable of being established between the telemetry unit and a control unit which is located outside the body.

6. Implant in accordance with one of the Claims 1-5, characterized by the feature that the valve is integrated into the telemetry unit.

7. Implant in accordance with one of the Claims 1-6, characterized by the feature that a pressure sensor has been connected to the measurement unit, whereby the pressure sensor measures the pressure drop across the valve.

8. Implant in accordance with one of the Claims 1-7, characterized by the feature that a pressure sensor has been connected to the measurement unit, whereby the pressure sensor measures the absolute pressure in the brain.

9. Implant in accordance with one of the Claims 1-8, characterized by the feature that a pressure sensor has been connected to the measurement unit, whereby the pressure sensor measures the difference in pressure between the first and the second free end of the catheter.

10. Implant in accordance with one of the Claims 1-9, characterized by the feature that the telemetry unit has a computer unit which evaluates the measured values, which are determined by the measurement unit, on the basis of prescribed target values.

11. Implant in accordance with Claim 10, characterized by the feature that test routines are implanted in the computer unit, whereby the test routines check the functional capability of the implant.

12. Implant in accordance with Claim 10, characterized by the feature that a memory for the measured values has been integrated into the measurement unit, whereby previous measured values are capable of being stored in the memory unit.

13. Implant in accordance with one of the Claims 1-12, characterized by the feature that the valve is a valve which is capable of being controlled electrically by the adjustment unit.

14. Implant in accordance with one of the Claims 1-13, characterized by the feature that a regulator has been provided which, depending on at least one measured status parameter of the valve and one prescribed target value, determines an adjustment parameter for the adjustment valve in such a way that the drainage characteristics of the cerebrospinal fluid correspond to the target value.

15. Implant in accordance with Claim 14, characterized by the feature that the regulator is integrated into the control unit.

16. Implant in accordance with Claim 14, characterized by the feature that the regulator is integrated into the telemetry unit.

17. Implant in accordance with one of the Claims 14-16, characterized by the feature that the measured status parameter is the pressure of the cerebrocpinal fluid in front of the valve and that the regulator is a PI regulator.

18. Implant in accordance with one of the Claims 1-17, characterized by the feature that the telemetry unit and the control unit have an oscillating circuit with, in each case, an inductance, whereby the oscillating circuit is capable of being tuned by the telemetry unit for the transfer of measured values and the oscillating circuit is capable of being tuned by the control unit in the case of the transfer of target values, and that data transfer takes place without contact being made via inductive coupling of the inductances.

19. Implant in accordance with Claim 18, characterized by the feature that the energy content of the frequency, that is transmitted from the control unit to the telemetry unit, charges up a storage battery and/or a capacitor for supplying energy to the telemetry unit.

20. Implant in accordance with one of the Claims 1-19, characterized by the feature that the control unit is connected to a computer system which evaluates the measured values, that are transmitted, and calculates the target values that are to be transferred.

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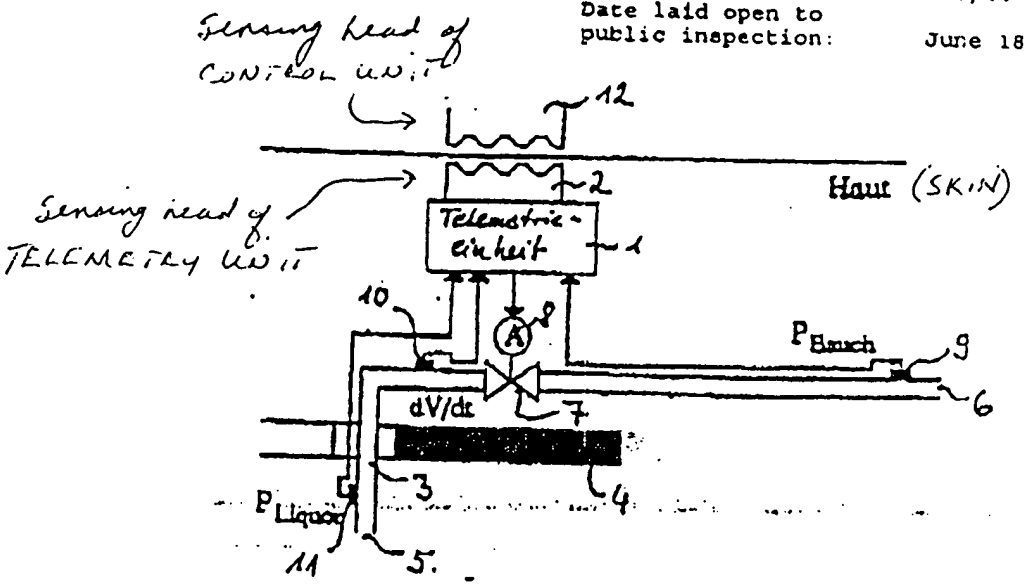
6 page(s) of drawings [are attached] hereto

DRAWINGS PAGE 1

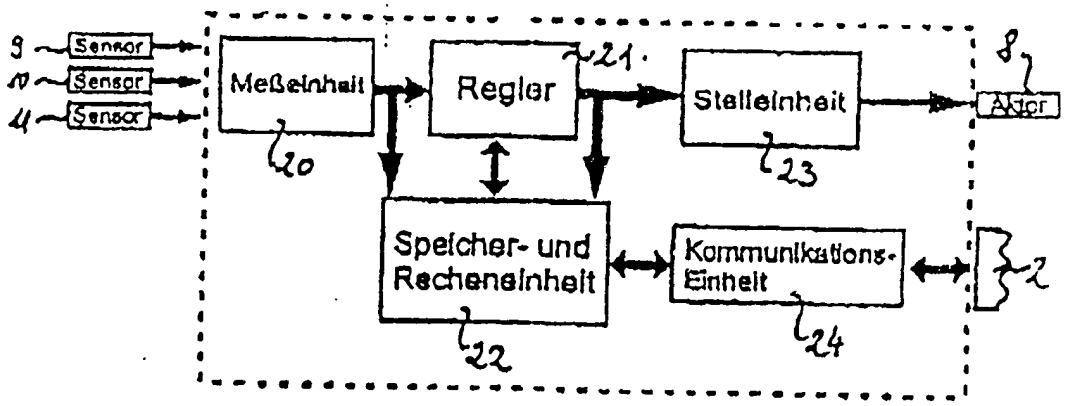
Number: DE 196 54 990 A1
Int. Cl.[6]: A 61 M 27/00
Date laid open to public inspection: June 18, 1998



KEY TO FIGURE 1

Haut	=	skin
Telemetrieeinheit	=	telemetry unit
P_{Bauch}	=	$P_{abdomen}$
P_{Liquor}	=	$P_{cerebrospinal\ fluid}$

Fig. 1



KEY TO FIGURE 2

Sensor	=	sensor
Meßeinheit	=	measurement unit
Regler	=	regulator
Stelleinheit	=	adjustment unit
Aktor	=	actor
Speicher- und Recheneinheit	=	memory and computer unit
Kommunikationseinheit	=	communication unit

Fig. 2

DRAWINGS PAGE 2

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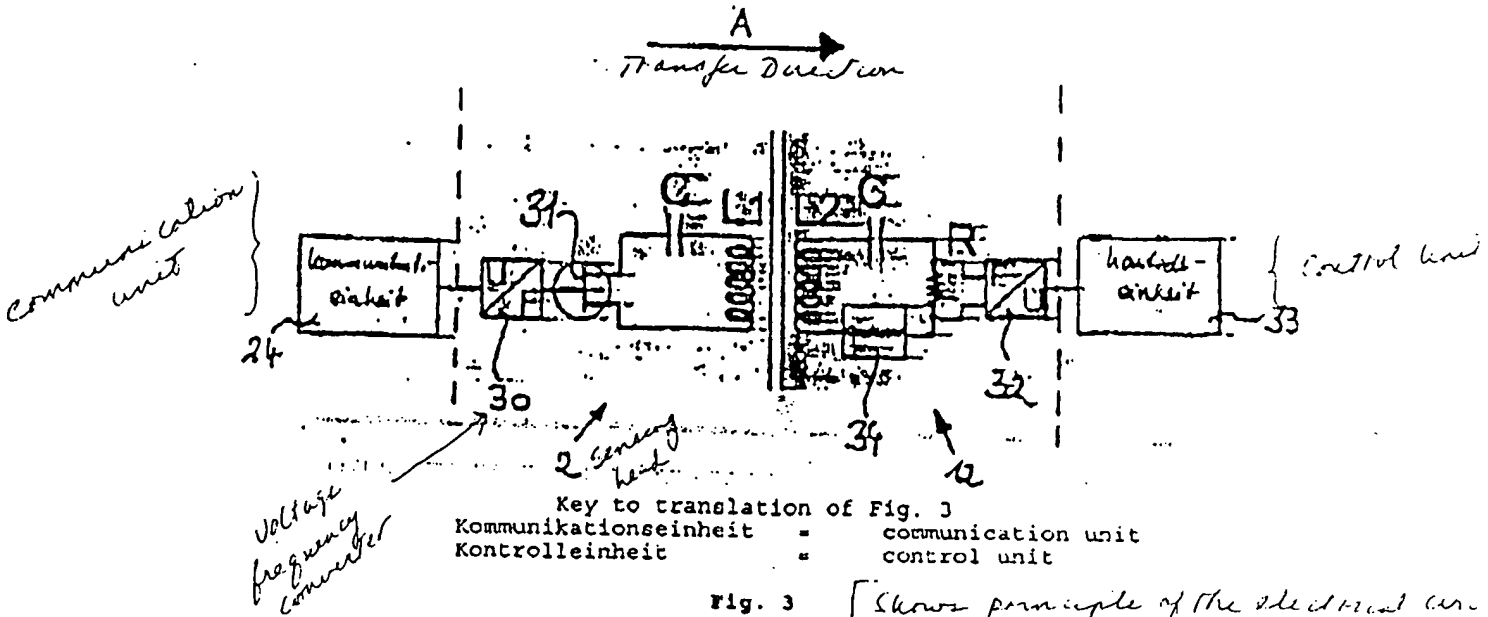
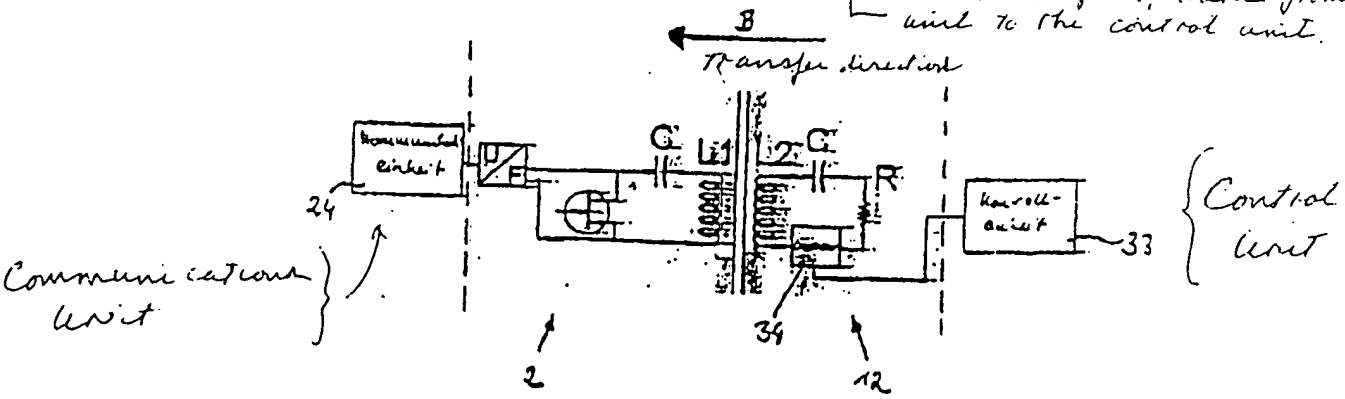


Key to translation of Fig. 3
Kommunikationseinheit = communication unit
Kontrolleinheit = control unit

Fig. 3

Shows principle of the electrical circuit for the transfer of data from telemetric unit to the control unit.



Key to translation of Fig. 4
Kommunikationseinheit = communication unit
Kontrolleinheit = control unit

Fig. 4

DRAWINGS PAGE 3

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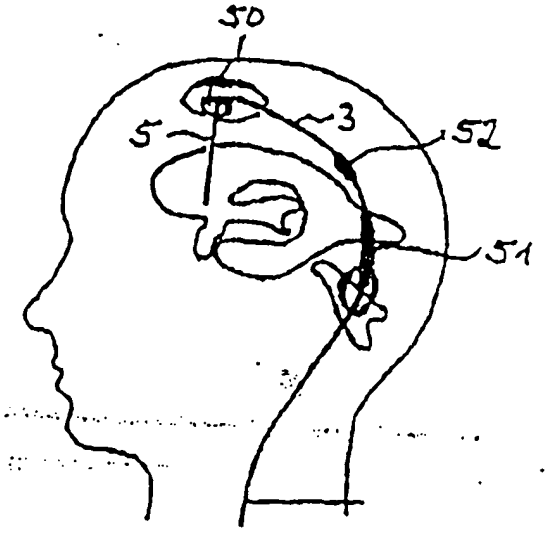

Fig. 5

DRAWINGS PAGE 4

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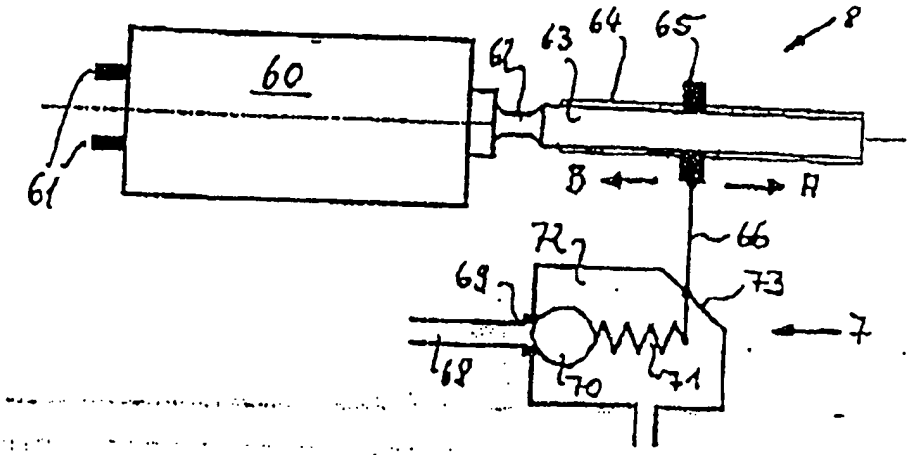

Fig. 6

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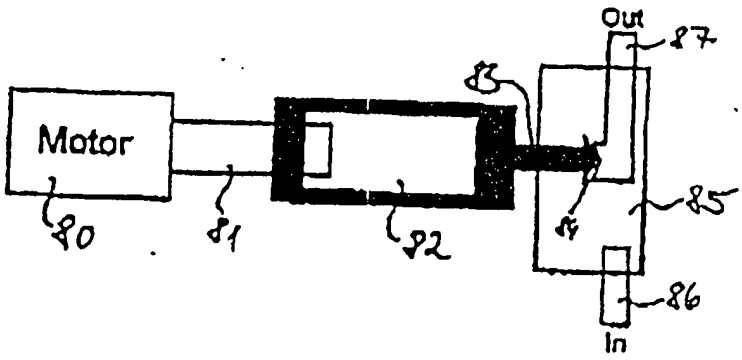
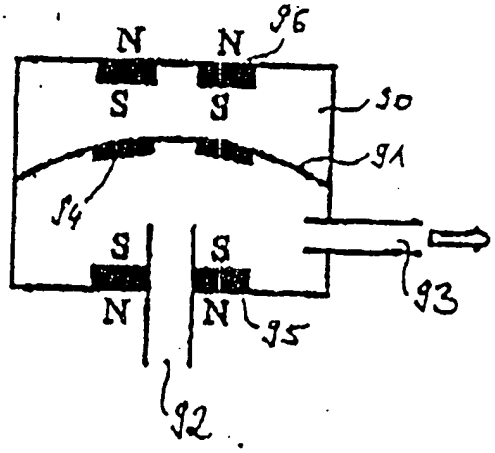


A proportional valve

Fig. 7



"Schematic representation" of A SPOOL TYPE VALVE

Fig. 8

DRAWINGS PAGE 6

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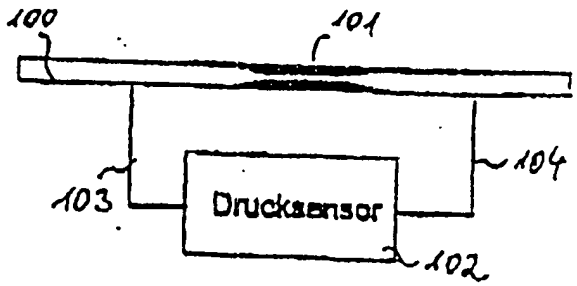
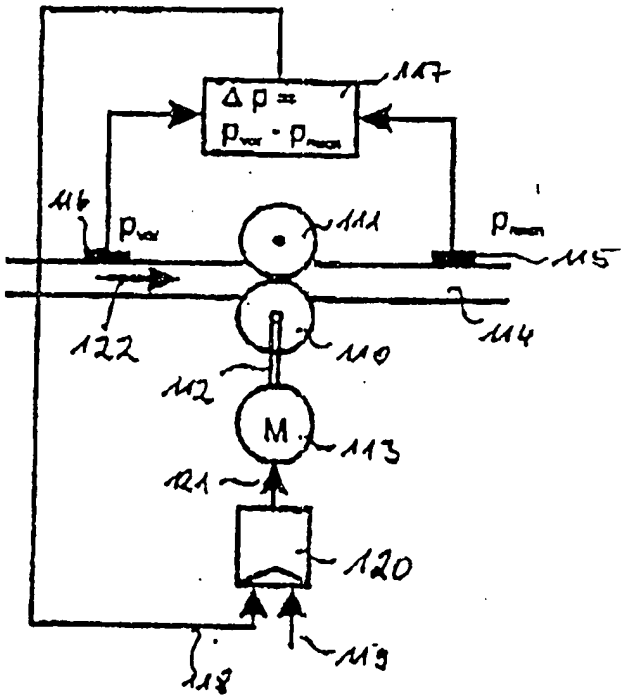


Schematic representation of a FLOW SENSOR

Key to translation of Fig. 9
Drucksensor = pressure sensor

Fig. 9



"Schematic representation of a FLOW SENSOR and a COMPLIANCE REGULATOR"

Key to translation of Fig. 10
vor = before
nach = after

Fig. 10